Univ J.

LIBRARY
FEB 3 1902
UNIVERSITY

JOHNS HOPKINS UNIVERSITY CIRCULARS

Published with the approbation of the Board of Trustees

VOL. XXI.—No. 155.] BALTIMORE, JANUARY, 1902. [PRICE, 10 CENTS.

NOTES FROM THE BIOLOGICAL LABORATORY.

EDITED BY PROFESSOR WILLIAM K. BROOKS.

RELATIONSHIPS OF THE RUGOSA (TETRACORALLA) TO THE LIVING ZOANTHEAE.

By J. E. DUERDEN.

When briefly discussing, in 1871, the Palaeozoic corals included under Milne Edwards and Haime's order Rugosa, the late Count Pourtalès thus remarks:—"Mr. R. Ludwig has shown (H. v. Meyer's Palaeontographica, Vols. X. and XIV.) that the tetrameral arrangement claimed for the Rugosa is only apparent, there being originally six primary septa; but that further development in each system is asymmetrical, and that two of the systems remain generally undeveloped. I had, before having knowledge of Ludwig's researches, come substantially to the same conclusions by the examination of *Lophophyllum proliferum* Edw. and H., from the carboniferous formation, a form very suitable for that study. . . . When the youngest stage of the coral is examined by cutting through the tip of the conical *Lophophyllum proliferum*, six primary septa and six interseptal chambers are found, placed symmetrically on two sides of a vertical plane, and unequally developed."

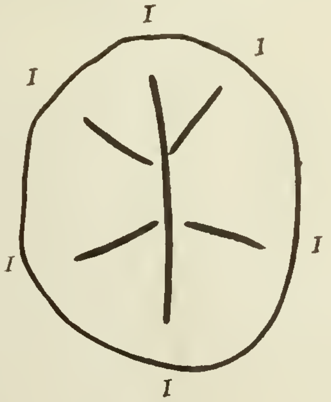


FIG. 1.

Transverse section through the tip of a corallum. The dark median lines of only six primary septa are present, but the outlines of the septa as a whole are not clearly determinable, their surfaces being fused throughout. The two median septa are represented by a continuous line, while the other four septa are arranged as an upper bilateral pair and a lower bilateral pair. Of the six primary interseptal spaces the two upper are slightly smaller than the others. By interseptal spaces may be here understood the interval between the dark lines of two contiguous septa; the septa are so broad as to occupy the whole of the calicinal cavity leaving no interseptal loculi. The descriptive terms upper and lower are used to merely indicate the position of the parts in relation to the section as a whole, and can have no morphological significance until the relationships of the different aspects of the coral with modern forms is established. In all the figures the upper border corresponds with the convex side of the coral, and the lower with the concave border; the primary septa are indicated by the Roman numeral I., and the later septa by the letters A-D, according to their order of appearance within the four primary interspaces.

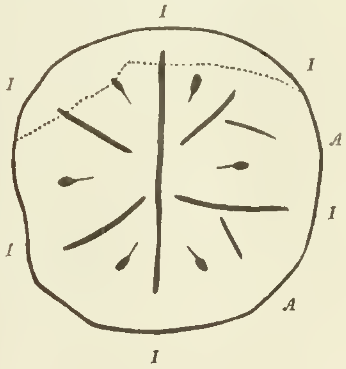


FIG. 2.

Transverse section through the tip of a second corallum, taken a little higher comparatively than the former section. The two median septa are still represented by a continuous line, and the lateral boundaries of all the septa are partly indicated by small oval interseptal loculi, which in the actual sections are filled with transparent calcite, or some opaque matter. In the drawings the loculi throughout are represented as opaque. Within the middle and lower primary interseptal spaces on the right side occur the dark lines of two new secondary septa (A), but no trace of any are seen on the left side. It is not unusual in modern corals for the growth of one region to be slightly in advance of that in another. The interrupted line towards the upper border of the figure marks the outline of the actual section. In this and some of the other figures the sections represented had been slightly fractured at one region or another during their preparation, but in order to give somewhat of symmetry to the drawings I have attempted restorations of the outline, the actual boundaries being indicated by the interrupted lines.

The very elaborate and painstaking researches of Ludwig, and the above definite statement of Pourtalès, have apparently never been accorded the full consideration they deserve in any discussion of the affinities of the Rugosa. Supported by the conclusions of

Kunth (1869), it seems to have been generally accepted by most students of this extinct group of corals that the adult arrangement of the septa around four principal members is sufficient evidence for assuming a primary tetrameral plan. The procedure is in some measure to be accounted for by the rarity with which the earlier stages in the growth of the septa of fossil corals are procured, and the difficulties involved in their investigation.

Tetramerism, both primary and secondary, has been the conception underlying most of the recent attempts which have been made to bring the Rugosa either into line with modern hexamerous corals, or to associate them with other groups; in the suggestions of Quelch (1886) and Ogilvie (1896), however, minor considerations of structure have prevailed. G. von Koch (1896), with his mature experience of coral morphology, has tried to show how from the six pairs of primary mesenteries, arranged as in recent corals, a primitive septal tetramerism might be obtained; while the distinguished Belgian naturalist, E. van Beneden (1897), assuming a primary four-rayed condition, places the group near the tetrameral Scyphomedusa, far removed from the hexamerous Madreporaria and Actiniaria.

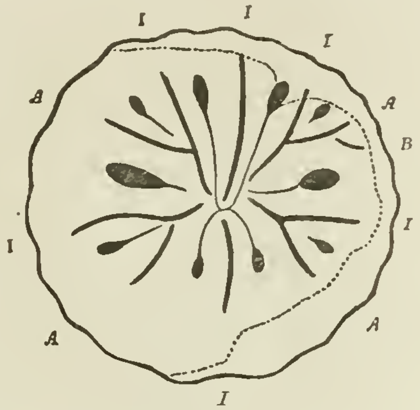


FIG. 3.

Transverse section towards the apex of a third corallum, taken at a little higher level than the two previous sections. The six primary septa are recognizable by their greater size, the outlines being indicated by the oval interseptal loculi and thin marginal lines; the two median septa are now distinct from one another, and the upper is larger than the lower, and is thereby already recognizable as the main or chief septum. The two upper primary interseptal spaces are much narrower than the middle and lower interspaces. Within each of the latter an additional septum (A) has appeared, and within the middle right interspace the rudiment of a second additional septum (B) occurs. No new septa are ever developed within the two upper interseptal spaces. As the calice increases in diameter the angle at which the primary septa are inclined to one another changes, owing to the intercalation of new septa at practically equal distances apart; hence the irregularity in form of the dark median line. In the inward growth of the new septa their inner extremities necessarily come into contact with the older septa already stretching as far as the middle, and thus give rise in lower sections to the appearance of branching. It is some time before all the septa become rearranged as true independent radii (cp. Fig. 6).

Recently the Geological Department of the United States National Museum has generously prepared for me serial transverse sections of several species of Palaeozoic corals,[1] for study in connection with certain results upon the mesenterial and septal arrangement in Madreporaria. Among these are several specimens of *Lophophyllum proliferum* (McChesney), the species investigated by Pourtalès. The fossils were collected from the Coal Measures, Springfield, Ill., and the preservation, even to the tip, is very perfect, while the practical absence of internal vesicular tissue enables the septal arrangement to be followed with every degree of certainty.

The preparations enable me to assert that *in each case the section through the tip of the corallum displays the median dark lines of six primary septa, separated by six interseptal spaces.* One example exhibits the six septa only (Fig. 1); another shows two rudimentary secondary septa in addition to the primary six (Fig. 2); while a third presents four secondary septa and the rudiment of a fifth (Fig. 3). The sections thus confirm in the most complete manner the statement made by Pourtalès thirty years ago, and serve to establish beyond a doubt the primary hexameral character of this one member of the Rugosa.

The six primary septa are represented in the sections at the tip of the fossilized coral as follows: a single continuous median dark line, denoting the two axial or directive septa, and on each side of this two other dark lines, which represent two bilateral pairs of septa. In later sections the single median line becomes replaced by two nearly equal lines (Fig. 3), which soon show the enormous difference in size characteristic of the "main" and "counter" axial septa of this species (Fig. 4). In the earlier sections the actual boundaries of each septum are not recognizable, but in transmitted light the dark median line representing the centres of calcification is very distinct all the way.

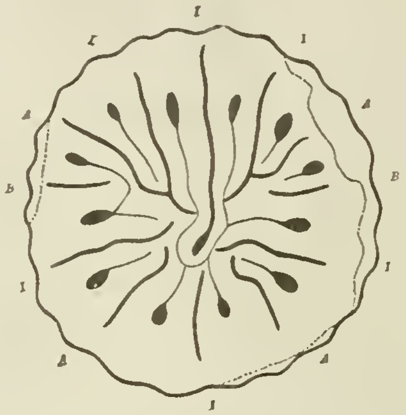


FIG. 4.

Transverse section of the same specimen, taken still further from the apex than that represented in the former figure. The larger or chief septum now extends much beyond the centre of the nearly solid calice; the opposite or counter septum is comparatively small; two well-developed additional septa (B) occur within the middle interseptal space on each side. The superficial ridges and grooves are moderately well marked in the section, and reveal that the median dark line of each septum corresponds with a groove, and that two ridges occur between every two adjacent septa.

It is also possible to determine the ultimate fate of the two bilateral pairs of primary septa. One pair forms the "alar" or lateral septa of palaeontologists, while the two moieties of the remaining pair, recognized by Ludwig and Pourtalès, but not accepted by Kunth, are disposed one on each side of the axial septum on the convex side of the calice.

The sections taken a short distance above the tip indicate that the subsequent septa are added within only four of the six primary interseptal chambers or systems, according to the law first recognized by Ludwig and also fully elaborated by Kunth, and likewise clearly indicated by Pourtalès in the septal scheme given on p. 50 of "Deep-Sea Corals." No new septa arise within the two remaining primary interseptal spaces. The sections further reveal that the small septa which in the mature coral alternate with all the larger or principal septa, do not make their appearance until the growth of the calice is nearly completed. From what is known of the relationship of the septa to the mesenteries in modern corals, the larger septal series evidently appeared within the entocoelic chambers of the polyps, while the smaller septa are exosepta. In the early stages of recent corals it is not unusual for the entosepta to appear in advance of the exosepta, but the interval would appear to have been enormously exaggerated in the present form, until, in fact, the full complement of entosepta had appeared.

---

[1] For the selection of the specimens and the supervision of the preparation of the sections I am indebted to Prof. C. Schuchert and Mr. T. Wayland Vaughan.

Not only are the serial transverse sections of *L. proliferum* favourable for the establishment of the primary condition of the septa, as well as the sequence of the later members, but the results can be confirmed in a most definite manner from the well-defined ridges and grooves occurring on the outer surface of the corallum. Sections through the lower part of the coral demonstrate that two external ridges correspond with each internal interseptal space, and each alternate groove corresponds with a septum; in the upper part of the calice, where the cycle of small septa has appeared, each ridge then corresponds with a single interseptal space, and each groove with a septum (cp. Figs. 6 and 8). On specimens of which the tip and the external surface of the coral are well preserved, twelve grooves and ridges, representing the six primary septa and interseptal spaces, occur practically as far as the apex, and can be followed all the way upwards, and the successive intercalation of the later septa at four regions can also be observed (Figs. 9, 10).

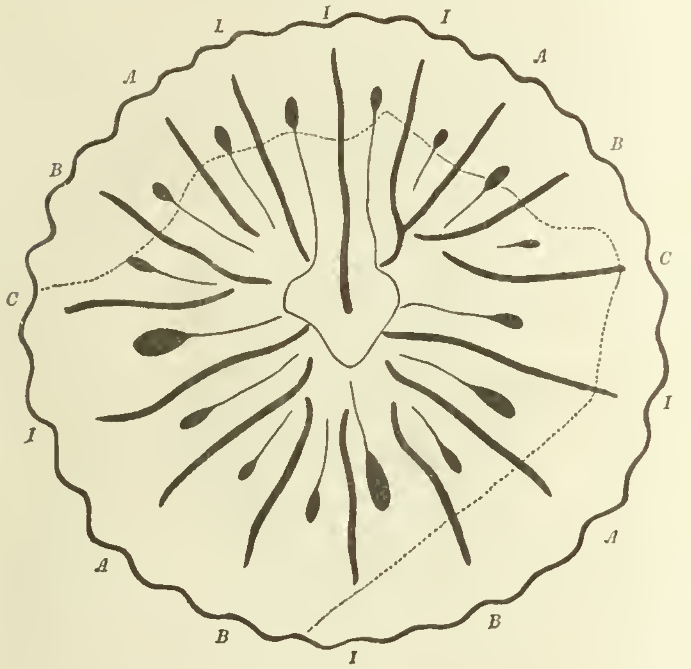


FIG. 5.

Transverse section from the same coral taken about the middle of its length. Compared with the previous figure an additional septum (C) has appeared within the middle chamber on each side, and also within the lower chamber on each side (B); so that now three secondary septa occur within each primary middle system and two within each primary lower system. Comparing all the figures thus far the new septa of the former series are seen to always appear immediately next the upper aspect of the lower lateral primary septum on each side, and in the latter series on each side of the lower axial or counter septum. Each new septum is intercalated between a primary septum and the last formed septum of the secondary series, in each case on the same aspect of the primary septum.

All the more recent studies on the Anthozoa indicate that the order of appearance and adult arrangement of the mesenteries are the surest guide to a phylogenetic or natural classification. In the divisions Actiniaria and Madreporaria, including the sea anemones and corals, two sharply distinguished stages in the appearance of the mesenteries are to be recognized, the one embracing the development of the six primary pairs of mesenteries (*protocnemes*), and the other the development of all the later mesenteries (*metacnemes*). With a few exceptions the order of establishment of the six pairs of protocnemes is the same throughout the Actiniaria and Madreporaria, denoting these two to be a well-defined, primitively hexamerous group. With the appearance of the later mesenteries however divergences are introduced which are to be regarded as of the most fundamental importance in actinian and coral morphology.

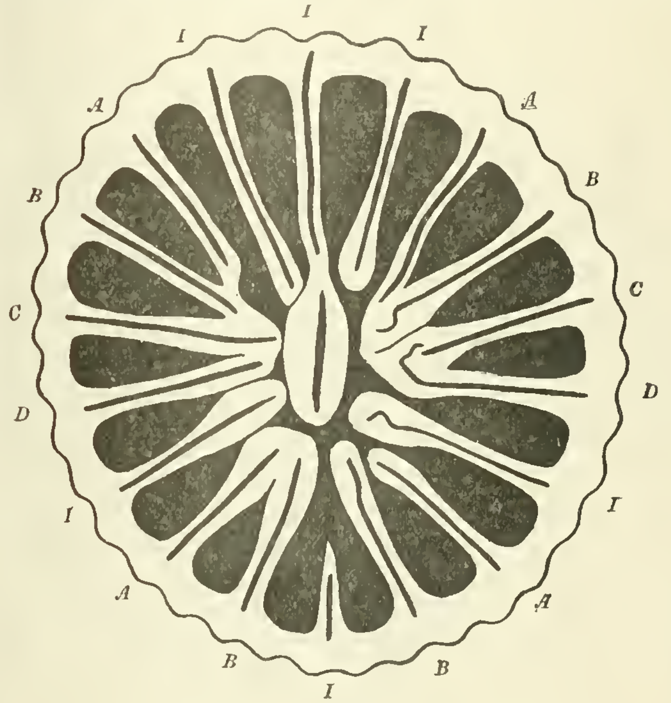


FIG. 6.

A transverse section taken towards the upper part of the same corallum as before. The septa are now comparatively thinner, and wide interseptal chambers occur. The former are yet swollen and partly fused at their inner extremity. The chief septum is enlarged at its middle extremity, constituting a nearly free columella, and the counter septum is greatly reduced. Compared with the previous section an additional pair of septa occurs (D), but excepting the two axial septa the different members are so nearly alike in size as to render it impossible to determine from this source alone whether the new pair has arisen within the middle or the lower systems. A serial section coming somewhat earlier, but too much fractured to be drawn with the camera, shows distinctly a very small septum on the upper aspect of the lower pair of primary septa, and in this later section I interpret them as being represented by the septa, D, D. All the sections indicate that growth proceeds more rapidly within the middle system than within the lower. Four bilateral pairs of secondary septa now occur within the middle systems, and only two bilateral pairs within the lower systems. Some variation exists in the different calices with respect to the number of septa arising in each system, but in most mature calices of the species four new pairs of septa are developed within the middle systems and three pairs within the lower systems.

Three distinct types of metacnemic succession are recognizable. In by far the majority of recent corals and anemones the new mesenteries arise successively as unilateral pairs, within each of the six primary exocoelic chambers, and in the end constitute alternating hexameral cycles; in the Zoantheae, as the researches of von Koch (1880), Erdmann (1885), and many others have shown, the new mesenteries are developed at only two regions, the exocoele on each side of the ventral directives, and the adult polyps are strongly bilateral (Fig. 12); in the perforate corals *Porites* and *Madrepora* I have recently found that the mesenteries beyond the six primary pairs appear as bilateral pairs, within the directive or axial entocoeles, thus recalling the method of mesenterial growth characteristic of the Cerianthidea after the formation of the first four pairs (1900).

It remains to be seen how close the septal conditions occurring in *Lophophyllum* can be brought into relationship with those of modern corals or the mesenterial plan of Actinians. The late Prof. H. de Lacaze-Duthiers (1873, 1897) and G. von Koch (1882, 1897) have described the primary stages in the formation of the corallum of living species of *Astroides*, *Caryophyllia*, etc., and in all cases either six or twelve septa are formed simultaneously; in the course of the post-larval development of the West Indian corals *Manicina areolata*, *Favia fragum*, and *Siderastraea radians* I have also found that six septa first appear, arising within the entocoelic chambers of the six primary pairs of mesenteries. Thus the protosepta are hexameral in all the representatives of the three sections of living corals—Aporosa, Fungacea, and Perforata—whose early development has been followed.

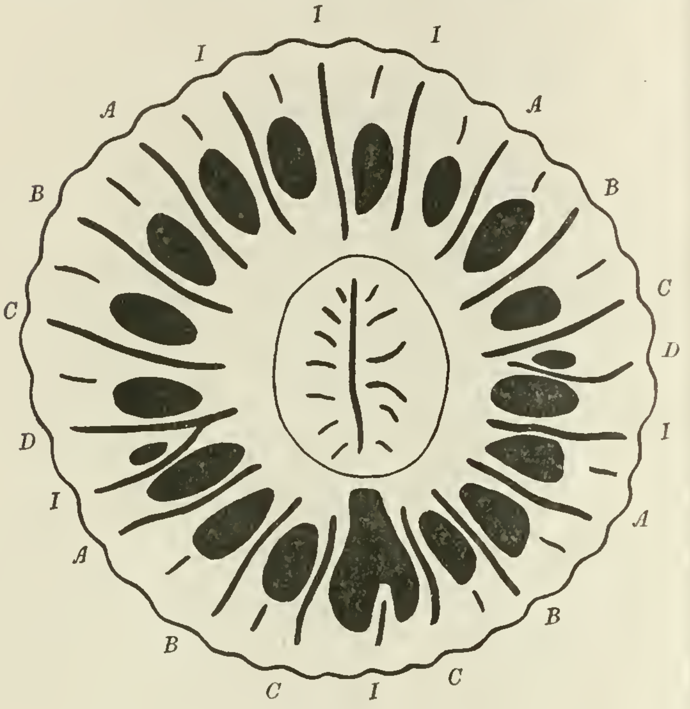


Fig. 7.

Transverse section towards the upper region of a fourth individual coral, before the projecting columella becomes free from the septa. The middle of the section is occupied by the large columella with which the septa are fused; the different centres of calcification show that the columella at this region is formed of the fused enlarged middle extremities of the chief septum and the lateral septa. The section is of particular interest as showing the late appearance of the small alternating septa. In all the previous sections no trace of these was present, but they are here represented by dark centres of calcification within the thickened thecal wall. A septum occurs between every two adjacent larger septa, so that the total number of septa now corresponds with the number of superficial grooves; in higher sections and in mature corallites the small septa are seen as distinct projections from the inner surface of the wall. The additional smaller septa therefore appear practically simultaneously, and only when growth is nearly completed; they have thus no sequence value whatever; only the larger septa are of importance in this direction. The section already shows the formation of the septal fossula by the coalescence of the two interseptal chambers one on each side of the counter septum.

As far as the protoseptal stage therefore the hexameral plan of its primary septa at once places the Palaeozoic *Lophophyllum* in agreement with recent Madreporarian corals, and renders unnecessary any attempt to account for a primitive tetramerism.

It is otherwise however with the subsequent stages of development. Very few observations have been made upon the actual manner of appearance of the secondary septa in corals; but in practically all modern species the septa beyond the primary six are found disposed within the six interspaces separating the primary members, and ultimately they are radially arranged in regular alternating hexameral cycles, just as are the mesenteries. Certain exceptions to this general plan occur, but do not in any way introduce any distinct fundamental type, except in the case of the genera *Porites* and *Madrepora*, where new septa arise within the axial or directive entocoeles, that is, in the position occupied by the primary axial septa.

The later septa in *Lophophyllum*, as in most other Zaphrentoid corals, arise bilaterally within only four of the six primary interspaces, and in the adult never assume a cyclical arrangement, but remain bilateral. It is the first characteristic which fundamentally distinguishes the form from any known modern coral, and in any natural taxonomic arrangement must call for its sharp separation as the representative of a distinct group. Though agreeing as concerns the protoseptal stage, the metaseptal sequence shows *Lophophyllum* and modern cyclical corals to be widely divergent.

The Palaeozoic corals sufficiently resemble those of modern days to warrant the assumption that the general relationships of the polyp to the corallum were the same as those now fully understood, and therefore, knowing their septal sequence, we can assume what must have been the mesenterial. With such a metaseptal sequence as that above demonstrated, both by the serial sections and by the external ridges and grooves, modern coral morphology permits the assertion that in the polyps of *Lophophyllum* new mesenteries were successively developed within four of the primary exocoelic chambers, and at only one region in each, immediately next a primary pair of mesenteries. Though no known living coral presents such a mesenterial sequence, yet it bears the closest resemblance to what is found to be characteristic of Zoanthid polyps, except that here the mesenterial increase takes place in only two exocoelic chambers, whereas in *Lophophyllum* the process was carried on in four chambers. The researches of E. van Beneden (1890) and McMurrich (1891) have established that the protocnemic stage in the Zoanthids is hexameral, and such must also have been the case with the extinct coral; the metacnemes arise in succession within two exocoelic chambers in Zoanthids,

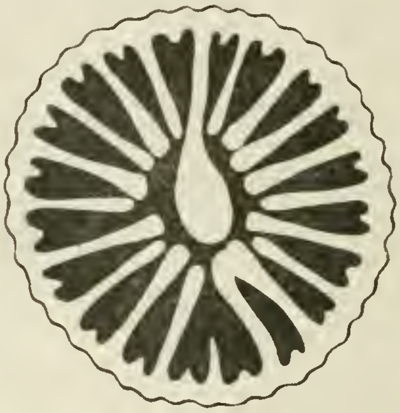


Fig. 8.

Upper surface of a polished specimen showing the alternating small septa which occur only towards the upper region of the calice. The principal septa, with the exception of the main and counter axial septa, are now practically equal in size and radially arranged, presenting little evidence of their successive origin in bilateral pairs. In such a figure it is impossible to determine the ordinal value of the septa, but the total number present agrees with that in the previous figure. The dark median lines are not seen by reflected light.

in the coral they appeared successively within four similar chambers. In Zoanthids the incompletion of the directives at one axial extremity and their completion at the other extremity may with good reason be correlated with the usual difference in size between the main and counter septa of the Rugosa; also some such relationship may perhaps hold between the complete (Macrotype) or incomplete (Microtype) sixth protocnemic pair and the enlarged or diminutive alar septa. The presence of a gonidial groove at one extremity of the stomodaeum in the Zoanthids and its absence from the other border still further conform with the marked difference between the two extremities in the Rugose coral (cp. Figs. 8 and 12).

The ontogeny of *Lophophyllum proliferum*, both in its primary and secondary phases, is thus in fullest agreement with the history of living types known to the Actinologist; not, it is true, with any coral type, but with a group of the closely related Actiniaria. So far as *Lophophyllum* can be taken as a representative, the peculiar septal plan of the Rugosa introduces no new conception into Anthozoan studies; and any other peculiar features which the order possesses, such as tabulae and vesicular endotheca, are of very subordinate morphological importance compared with the septal scheme.

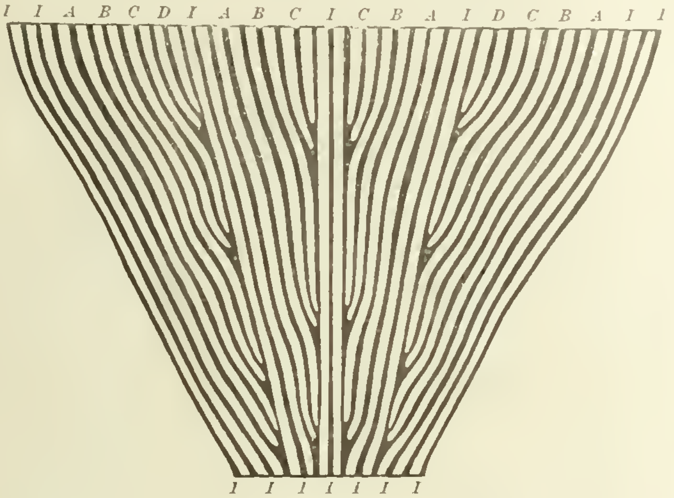


Fig. 9.

Diagrammatic representation of the grooves and ridges occurring on the external surface of the thecal wall. The black lines represent the grooves, the intervening spaces the ridges. The coral is supposed to have been opened vertically along its convex border and flattened out and viewed from the concave side. The sections have shown that the larger septa correspond only with alternate grooves, hence new ridges always appear in pairs not singly. The middle line corresponds with the small counter septum, the one on each side of this with the small septa, one on each side of the counter septum. New septa have been added successively on each side of the counter septum, always at one region, so that as new members appeared the older have been pushed further away. In the present instance three principal septa (A, B, C) have appeared on each side of the counter septum, between it and the lateral or alar primary septum. In the space between the lateral primary septum on each side and the dorsal lateral septum four principal septa (A, B, C, D) have arisen in succession, in each case in the region immediately beyond the alar or lateral septum. No septa have appeared between the upper lateral primary septa and the main septum. Only twelve ridges and twelve grooves continue as far the apex of the coral, representing the primary six septa and their interspaces.

A comparison of the septal plan in *L. proliferum* with the numerous figures of Zaphrentoid corals given in the works of Ludwig and Kunth reveals a unity of arrangement in very many cases, and from the scanty evidence yet adduced there is no reason to suppose that the primary septal plan was in anyways different from that here established, though in many cases actual proof may not be forthcoming. Kunth everywhere assails the hexamerism of Ludwig, yet he nowhere produces direct evidence of a primary tetrameral condition; indeed, I have not come upon any figure by any author representing a section of a primary four-rayed condition in the Tetracoralla. The converse is however true. Both Duncan (1867) and Kunth (1869), apparently independently, have found certain species of the Palaeozoic *Heterophyllia* to be primarily hexamerous. As a result of this the former writer connects them with the Mesozoic and recent Astraeidae, though acknowledging that certain of their other characters ally them to the Cyathophyllidae. There now seems every reason to suppose that the primary hexamerism of *Heterophyllia* is to be associated with that of *Lophophyllum*, and that the subsequent development follows the same essential plan in both. It is impossible to accord the same treatment to *Lophophyllum* as that to which *Heterophyllia* has been subjected; in the former the addition of the metasepta according to Kunth's law effectually prevents any suggestion of an Astraean character. Considering how universal is the hexameral protocnemic stage in modern corals and anemones, it would not be suprising to find it a fundamental characteristic of the Madreporaria of Palaeozoic times.

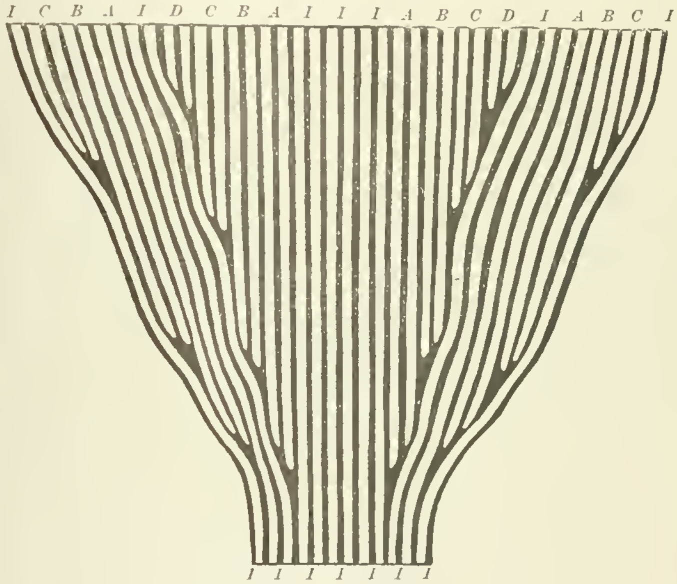


Fig. 10.

Diagrammatic representation of the superficial ridges and grooves of the same coral as before, seen from the convex aspect. The coral is supposed to be laid open along its concave border and then flattened. The main septum is represented by the middle line, and the counter septum by the boundary line at each lateral extremity of the figure. The other septa are as before, only the order is reversed.

F. Frech (1885) has also described and figured a new genus and species of Rugose coral, *Decaphyllum Koeneni*, in which the smallest specimens possess six large and six small alternating septa, exactly recalling the protoseptal stage of modern hexamerous corals. In the fully developed corallites an additional pair of septa has appeared within the two primary systems towards each axial border. Frech considers two opposite members of the smaller cycle to represent the main (Hauptseptum) and counter (Gegenseptum) septa, and attempts to derive the later stages according to Kunth's law of septal increase. Considering the septa, however, from the standpoint of modern coral morphology, the members of the small cycle are undoubtedly exosepta, and can scarcely be regarded as axial, or possess much value as indicating septal sequence.

In a later paper, Frech (1885a) has attempted to derive a primary tetrameral septal plan from the different mesenterial stages in the development of Actinian larvae as presented by Lacaze-Duthiers in 1873. In doing so, however, he assumes septal and mesenterial relationships differing from any yet established in Zoantharian morphology.

The most recent studies of the Actiniaria and Madreporaria tend to establish a wide division between ordinary anemones and corals, with a cyclical arrangement of the mesenteries, and the Zoanthids and Cerianthids, with a strongly bilateral symmetry. The separation is really founded upon the mode of origin of the metacnemes in the three groups, adult symmetry in the Zoantharia counting for little compared with developmental history. The tendency is to regard each of the three groups as ranking in importance with any of the other great divisions of the Anthozoa, such as the Alcyonaria and Antipatharia. Considerations along such lines have induced van Beneden (1897) to remove the Ceriantheae altogether from their usual association with the Actinians, to make of them an order Ceriantharia, and to place them along with the Antipatharia under a single division, Ceriantipatharia.

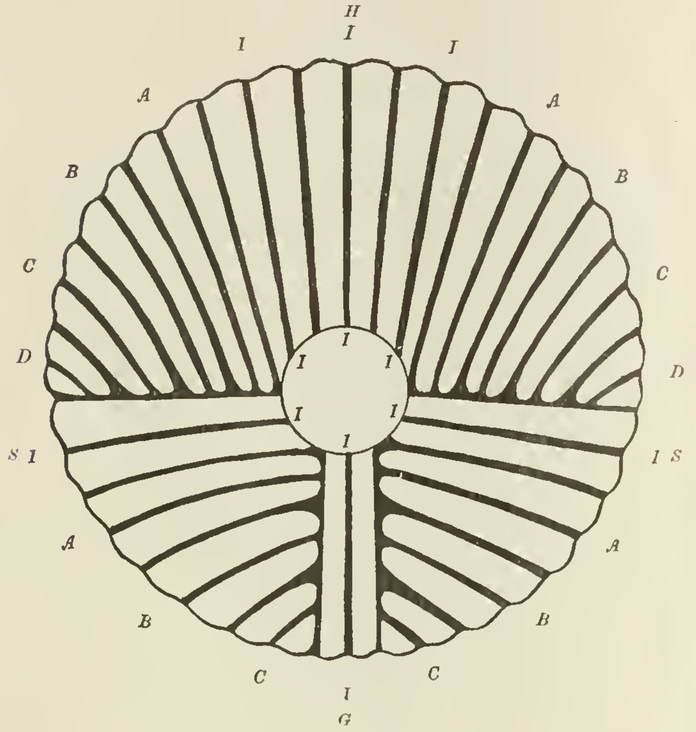


FIG. 11.

Diagrammatic representation of the ridges and grooves on the calicinal wall, as seen from below. The upper border of the figure corresponds with the convex side of the coral and the lower with the concave. The apex is represented as a circular area, instead of as a point, in order to better indicate the twelve primary ridges and grooves which extend thus far. On each side of the upper half the secondary septa (A, B, C, D) appear as radiating from the alar septum (S), the oldest lying next the primary septum adjacent to the main septum (H); on each side of the lower half the septa (A, B, C) radiate from the counter septum (G), the oldest lying next the alar septum.

Comparing the schematic figure with that of *Streptelasma* given by Kunth (1869, p. 647), and copied into most of the text-books on palaeontology, it will be seen that the positions at which the septa are added in *Lophophyllum* are the reverse of those in *Streptelasma*. In the latter genus, as appears to be also the case in most Zaphrentoids, the new septa in the main quadrant are added immediately on each side of the main septum, the oldest being next the alar septa; while in the counter quadrants they are added immediately adjacent to the alar septa, the oldest being next the counter septum.

It is quite certain that the Rugose corals with a metaseptal sequence at all resembling that of *Lophophyllum* can not be associated with other corals, recent or extinct, in which the metasepta arise within all the primary exocoeles; nor can they be placed along with the Ceriantheae, where growth is axial, as was suggested by Lindström in 1868. As already pointed out by Neumayr (1889), the considerations which induced Quelch in his report on the "Challenger" reef-building corals to class the Rugosa with modern Aporosa are altogether of secondary importance, and the same must be said of the attempt of Ogilvie (1896).

Supremacy being accorded the manner of mesenterial development as indicating natural relationships, the bilateral Zoanthids, primarily hexameral but with their metacnemic development restricted to two exocoelic regions, are, more than any other Anthozoan type, the modern representatives of the Rugosa. The Zoanthids, like the reef-corals with which they live associated, flourish to-day only in tropical seas; they would seem to represent an old fashioned Actinian type which has been preserved as a result of the habit of forming an incrusting skeleton and often compact colonies. In the past they no doubt bore much the same relationship to the Rugose polyps which the ordinary Actinians of to-day do to the majority of recent corals.

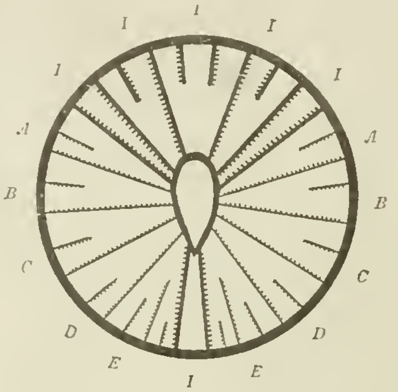


FIG. 12.

Diagrammatic representation of the mesenteries in a macrotypic Zoanthid. Five pairs of primary mesenteries, represented by thicker lines, occur at the dorsal aspect of the polyp, while the pair of sulcar directives is ventral. New mesenteries, represented by fainter lines (A–E), are added in succession within the exocoelic chamber on each side of the ventral directives, the oldest (A) being next the dorsal group of primary mesenteries. It will thus be seen that in the living Zoanthids new mesenteries are successively added at only one exocoelic region on each side of the polyp, while in *Lophophyllum* they were added at two regions on each side. The entocoelic chamber of the incomplete dorsal pair of directives in the Zoanthids will correspond with the large chief septum of *Lophophyllum*, and the entocoele of the complete ventral pair of directives, enclosing the siphonoglyph or gonidial groove, will correspond with the small counter septum and septal fossula of *Lophophyllum*.

The following arrangement will best indicate the different fundamental types of metacnemic sequence now known within the Actiniaria and Madreporaria, and the position amongst them of the Rugosa. With the exception of the Ceriantheae all possess a primary hexameral stage, consisting of six pairs of mesenteries with six primary entocoelic chambers and six primary exocoelic chambers. Calcareous septa may appear within only one or both series of chambers. It is in the succession of the later mesenteries and septa—metacnemes and metasepta—that the divergences are introduced.

1. The metacnemes arise as unilateral pairs at one, three, seven, etc., regions within all the six primary exocoeles, and become arranged in one, two. three, or more cycles:

a. Non-Skeletal.	b. Skeleton-Forming.
Most Actinians.	Most recent Madreporarian corals.

2. The metacnemes arise as bilateral pairs at only one region within two or more of the primary exocoeles:

a. Non-Skeletal.	b. Skeleton-Forming.
Zoanthids.	*Lophophyllum*, and probably other Rugosa.

3. The metacnemes arise as bilateral pairs at one region within one or both of the axial entocoeles:

a. Non-Skeletal.	b. Skeleton-Forming.
Cerianthids.	*Porites, Madrepora.*

References.

1862. Ludwig, R. "Actinozo̊en und Bryozoen aus dem Carbon-Kalkstein im Gouvernement Perm." Palaeontographica, X.
1865. Ludwig, R. "Corallen aus Paläolithischen Formationen." Palaeontographica, XIV., 1865-66.
1867. Duncan, P. M. "On the Genera Heterophyllia, Battersbyia, Palaeocyclus and Asterosimilia." Phil. Trans., CLVII.
1869. Kunth, A. "Beiträge zur Kenntniss fossiler Korallen." Zeits. der Deutsch. geol. Gesselsch., XXI., 1869; XXII., 1870.
1871. de Pourtalès, L. F. "Deep-Sea Corals." Illustr. Catalogue Mus. Comp. Zool. Harvard College, IV.
1873. Lacaze-Duthiers, H. de. "Développement des Coralliaires. Deux. Mém. Actiniaires a Polypiers." Arch. de Zool. Exp. et Gen., II.
1880. von Koch, G. "Notizen über Korallen." Morph. Jahrb., VI.
1882. von Koch, G. "Ueber die Entwicklung des Kalkskeletes von *Asteroides calycularis* und dessen morphologischer Bedeutung." Mitt. a. d. Zool. Stat. zu Neapel, III.
1885. Frech, F. "Die Korallenfauna des Oberdevons in Deutschland." Zeit. d. D. geol. Ges., XXXVII.
1885^{a}. Frech, F. "Ueber das Kalkgerüst der Tetrakorallen." Zeits. d. D. geol. Ges., XXXVII.
1885. Erdmann, A. "Ueber einige neue Zoantheen." Jenaische Zeitschr., XIX.
1886. Quelch, J. J. "Report on the Reef Corals." Challenger Reports, Zoology, XVI.
1889. Neumayr, M. "Die Stämme des Thierreiches." I. Wien und Prag.
1890. van Beneden, E. "Une Larve voisine de la Larve de Semper." Arch. de Biologie, X.
1891. McMurrich, J. P. "Contributions on the Morphology of the Actinozoa. III. The Phylogeny of the Actinozoa." Journ. Morphol., V.
1896. von Koch, G. "Das Skelett der Steinkorallen." Leipzig.
1896. Ogilvie, M. "Microscopic and Systematic Study of Madreporarian Types of Corals." Phil. Trans., CLXXXVII.
1897. von Koch, G. "Entwicklung von *Caryophyllia cyathus.*" Mitt. a. d. Zool. Stat. zu Neapel, XII.
1897. van Beneden, E. "Les Anthozoaires de la Plankton-Expedition." Résultats de la "Plaukton-Expedition der Humboldt-Stiftung." II., Kiel et Leipsic.
1897. Lacaze-Duthiers, H. de. "Faune du Golfe du Lion. Coralliaires. Zoanthaires Sclérodermés." Archiv. de Zool. Exp. et Gen., 3 Ser., V.
1900. Duerden, J. E. "Order of Appearance of the Mesenteries and Septa in the Madreporaria." Johns Hopkins University Circulars, XIX., No. 146.

NOTES ON THE ANATOMY AND HISTOLOGY OF A NEW FORM OF CLADONEMA FROM THE BAHAMAS.

By H. F. Perkins.

Genus: Cladonema, Dujardin, 1843.

Generic Characters: Cladonemidae with 8 or 10 radial canals, arising singly, or in pairs fused at their origin and for a short distance beyond. Manubrium with 4 to 6 external pouches about the median zone. Oral tentacles, 4 or 5, terminated by spherical knobs of lasso-cells. Tentacles equal in number to radial canals, and continuous with them; branched, or with tentacular appendages simple or branched; appendages arise alternately from the distal portion of the tentacles, are more or less extensile, and bear lasso-cells and cement-cells.

Characters of Form from Bahamas.

Height of bell about equal to diameter, less than 2 millimeters. Radial canals 8, arising singly. Tentacles 8, unbranched. Tentacular processes, usually 8 to 10, unbranched. 5 or 6, situated distally, bear nodules and terminal capitula consisting of both cement-cells and nematocysts. 3 or 4 proximal processes smooth, with capitula same as above. Bell transparent, with reddish brown markings at ocelli and bases of tentacles.

It has been found necessary to revise the diagnosis of the genus as given by Haeckel[1] and Allman.[2] This was made to include a description of the two kinds of tentacular processes or cirri which are a marked characteristic of the European form. While it is certain that the medusa from the Bahamas is generically similar to the C. radiatum of Dujardin, there is such a striking difference in the form of the tentacular appendages that it is necessary to drop the detailed description of these parts from the enumeration of the generic characters. The above diagnosis is therefore so framed as to include the form which is described in this paper, and to leave room for any intermediate forms which may happen to appear later.

In regard to the Cladonema from the Bahamas, there are differences between it and the C. radiatum of Dujardin so marked and important as to seem amply sufficient for the establishment of a new species to accommodate it, were it not for the fact that the representatives of this genus are extremely variable. This latter consideration, however, makes it seem best to withhold judgment as to whether or not this is a new species until such time as there is a greater variety and range of material for comparison.

The material for this paper was found in July, 1901, in the tow, taken at night in the vicinity of Nassau Harbor. I was greatly assisted in my collecting by the coöperation of Rev. F. W. Gostick of Nassau. I wish to acknowledge also my indebtedness to Professor W. K. Brooks, under whose direction the specimens were studied in the laboratory.

Description.

The height of the bell in specimens of the adult Cladonema is a trifle greater than the diameter. The walls of the umbrella are of uniform thickness throughout. The surface of the umbrella forms a complete and even dome, devoid of any elevation at the summit.

---

[1] Haecket, E. 1879. Das System der Medusen.

[2] Allman, 1872. Monograph on the Hydroids.

The *manubrium* is very large, and contains a capacious stomach. Its lower or distal end hangs down as far as or below the level of the bell-margin. At the top it sends off eight radial canals from a crown-like circle of conical pouches, the top of the manubrium sinking down a little in their midst. The canals arch upward and outward from their origin, so that the manubrium appears as if suspended from the dome of the umbrella by eight ropes. The manubrium widens regularly to the level of its greatest diameter, which is at about its median zone. At this level are situated six rounded pouches, which project beyond the wall of the manubrium. As a matter of fact, these pouches are merely recesses in the wall of the stomach, and their structure appears to be the same as that of the rest of the manubrium. This is contrary to the description and figure given by Haeckel. He calls the pouches "gonads," and in his plate they are represented as filled with eggs. Allman, however, refrains from assigning any function to these protuberances, and furthermore, in no part of his description does he give any hint as to the origin of the reproductive elements, in the mature medusae from the European coast. The western form was studied in the hope of discovering something about the reproductive organs, and transverse sections were cut for this purpose. It was found that the sexual elements are developed in the ectodermal tissue of the six pouches; but it was also determined that the tissue immediately surrounding the pouches and indeed the ectodermal layer covering a large part of the manubrium, gives rise to ova and sperm. Ova in all stages of maturation were seen imbedded in the tissue of the manubrium in a specimen of which sections were made. Some other function must be assigned to the pouches. Inasmuch as they are lined with the same columnar endoderm as that which makes up the gastric tissue of the stomach, it is most probable that they are merely accessory digestive organs. The cavity of the stomach is very wide at the level of the pouches, its diameter being as much as three-fifths of the outside measurement of the bell. A great extent of surface is thus afforded for the digestive processes.

Below the pouches the manubrium diminishes in size toward the mouth, where its diameter is considerably less than at the attached end. Around the mouth are situated five oral processes or tentacles, each consisting of a short stalk, bearing a single spherical knob of lasso-cells. These oral tentacles are directed outwards and downwards.

The manubrium is thus seen to be a most remarkable structure, octameral at the top, hexameral in the middle, then cylindrical, and finally ending in a five-pointed star, with knobs on the points. The six diagrammatic cross-sections shown in Fig. 2 indicate the internal and external outlines, and the proportionate size of the manubrium at the various levels.

The conical pouches from which the *radial canals* take their origin are arranged like inverted funnels around the top of the stomach. Their tubes lead upward and outward to the wall of the bell, and then follow it in gentle curves downward to the bell-margin. They are very slender throughout their course, except at their origin and at their junction with the circumferential canal. Just behind the base of each tentacle the radial canal dilates into a little chamber from the bottom of which the two openings lead out into the circular canal.

The *velum* is a very wide and muscular membrane, with distinct circular striations. It forms an important part of the strong swimming apparatus which enables the medusa to dart about in the water at a surprising rate of speed.

The *tentacles* are the most noticeable feature of this interesting little medusa. They are directly continuous with the radial canals, and arise from the outer edge of the bell-margin by a rounded hip-like base (Fig. 1). Below its origin the tentacle widens rapidly for a short distance, owing to the presence of a ridge of cartilaginous tissue which lies across the tentacle just below the bell-margin. For two-thirds of its length the tentacle is cylindrical or slightly tapering; it then makes a slight bend outwards, *i. e.*, away from the axis of the bell, and from this point it diminishes in size to the tip. The surface of the tentacle is dotted here and there with nettling organs, which are nowhere gathered in masses of any size. The tip is blunt, and devoid of any nematocyst enlargement.

At the inner surface of the tentacle, where it bends outwards, occurs a rounded protuberance. From its surface arises the first of the *tentacular processes.* These processes, or cirri, are placed alternately on the lower surface of the tentacle, which is directed downward toward any object on which the medusa fastens itself. The number of these appendages varies greatly, in some mature specimens there being only three on each tentacle; the normal number, however, seems to be from 8 to 10. The three or four cirri which lie nearest the base of the tentacle are smooth except for the knob of cnidocysts at the tip. The first one in point of time and place of origin, arising from the rounded enlargement of the tentacle, is very short, being merely a stalked knob. The five or six cirri nearest the end of the tentacle are not only tipped with the ball of lasso-cells, but are nodulated along their course with numerous smaller groups of similar organs. This is apparently the only difference between the proximal and distal appendages in this form of Cladonema. Allman in his very full and beautiful description of C. radiatum gives much weight to the difference between the two kinds of tentacular processes. In his specimens the three smooth proximal tentacles alone were provided with suctorial organs but were devoid of nettling cells; the more distal ones, of which there were usually four or five, bore nematocysts only in their nodules and terminal knob. In the form from the Bahamas, on the other hand, *all* of the cirri bear both cement cells and cnidocysts (Fig. 4). Furthermore, whichever of the two types is the ancestral one, the fact that the creature when at rest fastens itself to the bottom by means of the cement cells on the nodules and capitula of *all* the cirri is additional proof of the change in function which has gone on. The great extensibility of the distal appendages in C. radiatum, as mentioned by Allman, which is so far developed that these cirri float in the water like some delicate seaweed, is absent in this form. Again, the cavity of the tentacles is said by Allman to extend into the distal appendages. This is another point of dissimilarity, the medusa from the Bahamas having solid processes.

The nodules of the distal cirri are in the form of elongated bunches of lasso cells and cement glands, and lie across the appendage, mostly on the side which is directed downward when the cirri are spread out over any surface. One or two clusters which lie near the tip of the cirrus are situated on the opposite side of the appendage (Fig. 4, *O*).

Ocelli: The basal enlargement of the tentacle, mentioned above, is caused by a pad-like mass of cartilaginous tissue which nearly encircles the tentacle (Fig. 5, *C. Ec.*) This pad is not unlike that which lies at the base of the tentacles in the Geryonidae, and in both cases serves to protect the sensitive nerve-tissue underneath it. The cartilaginous ridge is thickest on the outer face of

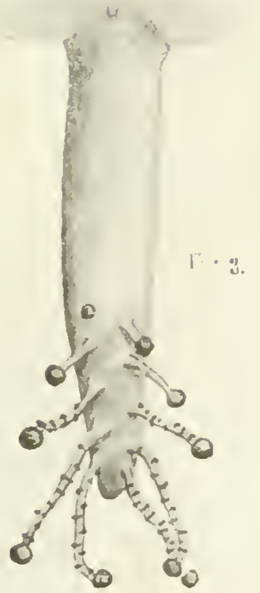


Fig. 3.

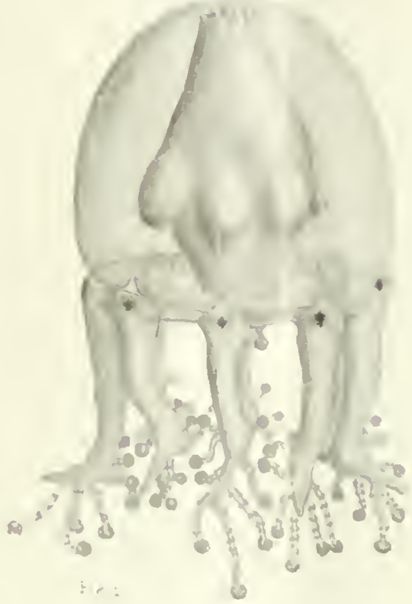


Fig. 1.

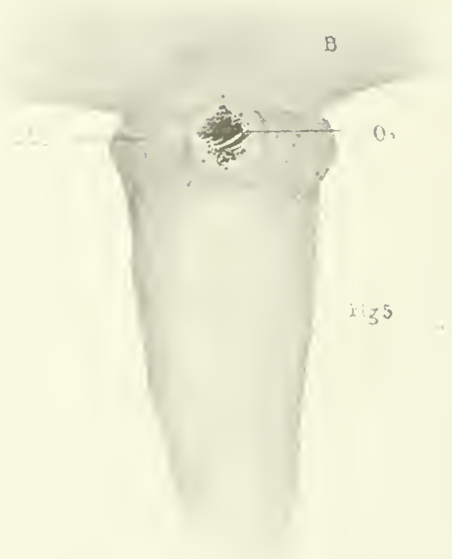


Fig. 5

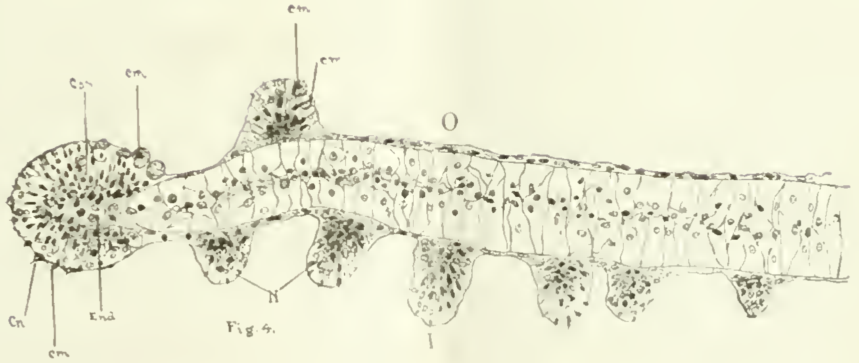
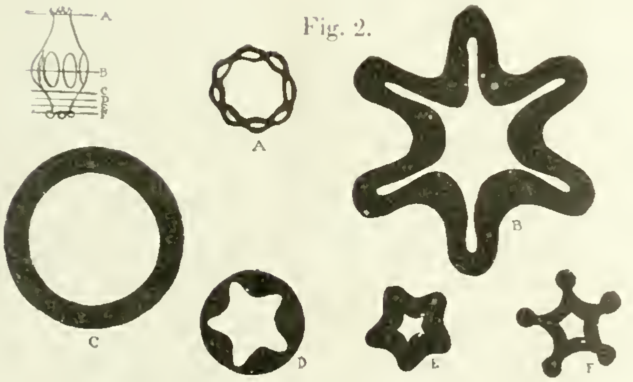


Fig. 4.

Fig. 2.



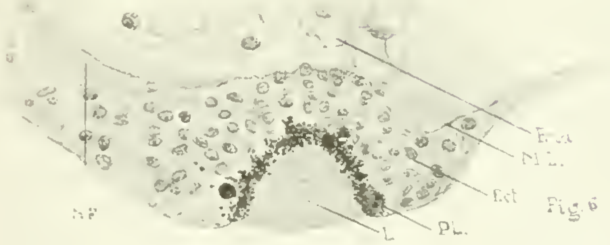


Fig. 6

Plate with paper on the Anatomy and Histology of a new form of Cladonema by H. F. Perkins.

Fig. 1. Adult *Cladonema* in the act of swimming. The tentacles and appendages are partially recovered from position of utmost extension, after an upward impulse.

Fig. 2. Diagrammatic cross-sections of manubrium, at various levels indicated in the key by lines lettered to correspond with the sections, *A*, *B*, *C*, *D*, *E*, and *F*. Illustrating transition in shape of organ from upper to lower extremity. *A*, 8–parted; *B*, 6–parted; *C*, cylindrical; *D*, *E*, *F*, 5–parted.

Fig. 3 Inner surface of tentacle, showing four smooth proximal and six nodulated distal cirri, and alternate arrangement.

Fig. 4. Optical cross-section of a nodulated cirrus. *Cap*, capitulum. *O*, surface turned up when at rest. *I*, inferior surface. End, endodermal core of cirrus and capitulum. *N*, nodules with cement glands, *cm*, and cnidocysts, *cn*.

Fig. 5. Base of tentacle seen from front, at its point of origin. *B*, bell-margin. *C. Ec*, calcarious ectodermal ridge. *Oc*, ocellus.

Fig. 6. Cross section of ocellus. *L*, lens. *P. L*, pigment layer, with scattered granules singly and in masses outside of distinct layer. *Ect.*, ectoderm, with calcarious concretions. *M. L*, muscular layer. *End*, endoderm. *N. F.*, nerve fibres from outer nerve-ring.

Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

http://www.archive.org/details/no155circular21johnuoft

the tentacle, opposite the axis of the bell. It is packed with granular concretions which are highly refractive and imbedded in the ectodermal epithelium. At this thickest place the ectoderm sinks down to form a deep cup, lined with a layer of pigment granules so closely packed as to give the eye-spot a very striking appearance as contrasted with the otherwise colorless body of the jelly-fish. Some of the pigment granules are scattered outside the definite layer; as they lie mostly at four points, just above, just below, and at either side of the rim of the ectodermal cup, they give the ocellus the appearance of a rectangular spot set cornerwise on the insertion of the tentacle (Fig. 5, *Oc.*)

The cavity of the cup is filled with a concretion, the *lens*, very convex on the side towards the axis of the bell, and nearly flat in front.

The ocellus is innervated by fibres which arise in the outer nerve ring.

The genus Cladonema has been an object of the admiring interest of Zoologists for a longer time than almost any other member of the great group of Hydromedusae. The first complete account of the life-history of any hydroid, including a description of the stages in an alternation of generations, was given by Dujardin in 1843. His research was carried out upon Cladonema radiatum, then described for the first time. Dujardin obtained his material from the northern coast of France. Since this time, various collectors have described as distinct species several forms which differ from Dujardin's only in the numerical arrangement of parts. The members of the genus are remarkable for their variability, and Haeckel considers the several forms as only subspecies. These are grouped as in the following table. The form from the Bahamas is given also for the sake of comparison.

Sub-Species of Cladonema Radiatum.

Name.	No. oral tentacles.	No. "Gonads" (Gastric pouches.)	No. Radial Canals		
			single.		double.
C. Gegenbauri...	4	4	8	or	4
C. Krohnii.......	4	4	10	or	5
C. Dujardinii....	5	5	8	or	4
C. Allmani.......	5	5	10	or	5
C. (Bahamas)...	5	6	8		

Heretofore, the genus Cladonema has not been described from any locality except the coast of northern Europe. The specimens upon which the present description is based possessed many interesting and beautiful features. The delicate transparent bells, shooting through the water with rapid systole and diastole, were barely visible. But when the medusa had pegged itself down, as it were, to the bottom of the glass vessel, and was examined by reflected light, it presented a very ludicrous appearance. It seemed to be standing on eight legs, much too large for the frail body, with long pointed feet and slender toes, tipped with bulbous suckers. These feet spread out over the bottom, and gave the little medusa such a hold that it required a thrust from the end of a pipette to dislodge it. Then it would suddenly dart off through the water at a remarkable rate, and elude the most careful search until it again settled down on its incongruous legs. In spite of its frail structure, Cladonema seems to be provided with very efficient means of evading its enemies and resisting the ocean currents, as well as of supplying itself with food.

MEMOIRS FROM THE BIOLOGICAL LABORATORY OF THE JOHNS HOPKINS UNIVERSITY.

Edited by Professor WILLIAM K. BROOKS.

VOLUME I.

SELECTED MORPHOLOGICAL MONOGRAPHS.

Three hundred and seventy pages and fifty-one plates, quarto.

CONTENTS.

Lucifer: a Study in Morphology, with 11 plates. By W. K. Brooks.
The Development of Renilla, with 16 plates. By E. B. Wilson.
The Life-History of the Hydro-Medusæ: a Discussion of the Origin of the Medusæ, and of the significance of Metagenesis, with 8 plates. By W. K. Brooks.
Report on the Stomatopoda, with 16 plates. By W. K. Brooks.
This volume is not sold separately.

VOLUME II.

MEMOIR ON THE GENUS SALPA.

By Professor W. K. Brooks.

Two parts, one part of text with three hundred and ninety-six pages, large quarto, and one part with fifty-seven large colored plates.

CONTENTS.

I.—A General Account of the Life-History of Salpa. Chapter I.—Introductory. Chapter II.—The Development of the Solitary Salpa from the Egg. Chapter III.—The Morphological Significance of the Salpa Embryo. Chapter IV.—The Origin of the Proliferous Stolon. Chapter V.—The Transformation of the Stolon into the Series of Aggregated Salpæ.
II.—The Systematic Affinity of Salpa in its relation to the Conditions of Primitive Pelagic Life; The Phylogeny of the Tunicata; and the Ancestry of the Chordata. Chapter VI.—The Systematic Position of Salpa. Chapter VII.—Salpa in its Relation to the Evolution of Life. Chapter VIII.—The Origin of the Chordata, considered in its relation to Pelagic Influences.
III.—A Descriptive and Critical Discussion of the Asexual and Sexual Development of Salpa. Chapter IX.—The Origin and Maturation of the Egg of Salpa. Chapter X.—Sex in Salpa. Chapter XI.—The Fertilization and Segmentation of the Egg. Chapter XII.—The Accessory Parts of the Embryo. Chapter XIII.—The Follicle and the Placenta. Chapter XIV.—The Ontogeny of the Organs of Salpa.
IV.—By M. M. Metcalf. The Eyes and Subneural Gland of Salpa.
Price for the two parts, $7.50, *net*.

VOLUME III.

THE COLLECTED PHYSIOLOGICAL PAPERS OF PROFESSOR H. NEWELL MARTIN.

Two hundred and sixty-four pages, quarto, and fifteen plates. Published by the friends and former pupils of Professor Martin.

This volume is not sold separately.

VOLUME IV.

SELECTED MORPHOLOGICAL MONOGRAPHS.

Two hundred and ninety-two pages and thirty-two plates, quarto.

CONTENTS.

I. The Cubomedusae. By Franklin Story Conant.
II. Synapta Vivipara. By Hubert Lyman Clark.
III. The Anatomy, Habits and Embryology of Yoldia Limatula. By Gilman Arthur Drew.
IV. Physiology and Histology of the Cubomedusae, including Dr. F. S. Conant's Notes on the Physiology. By Edmund William Berger.
V. Ophiura Brevispina. By Caswell Grave.
VI. The Anatomy and Development of Cassiopea Xamachana. By Robert Payne Bigelow.

Price, $7.50, *net*.

THE PRICE OF THE FOUR VOLUMES OF MEMOIRS IS FIXED AT $35.00, NET.

Orders should be sent to The Johns Hopkins Press,
Baltimore, Md.

PHOTOGRAPHIC REPRODUCTION OF THE KASHMIRIAN ATHARVA-VEDA.

THE
KASHMIRIAN ATHARVA-VEDA
(School of the Pāippalādas)

REPRODUCED BY CHROMOPHOTOGRAPHY
FROM THE
MANUSCRIPT IN THE UNIVERSITY LIBRARY AT TÜBINGEN

EDITED UNDER THE AUSPICES OF
The Johns Hopkins University in Baltimore
AND OF
The Royal Eberhard-Karls-University in Tübingen,
Württemberg

BY

Maurice Bloomfield, *Professor in the Johns Hopkins University* AND Richard Garbe, *Professor in the University of Tübingen*

BALTIMORE:
The Johns Hopkins Press
1901

The photographic reproduction of this unique manuscript is now completed. It contains 544 plates, 15⅜ x 12 inches. The technical work has been done with great success by the firm of Messrs. Martin Rommel & Co., of Stuttgart, and it is believed that no more handsome and satisfactory reproduction of such a manuscript has ever been made. The work has been reproduced in three parts, in temporary binding. The few copies of the volume not subscribed for in advance will be sold at the price of $50.00—a very low price considering the cost of the reproduction.

Orders may be sent to Mr. N. Murray, Johns Hopkins University, Baltimore, Md., U. S. A.

The preface to the work is reprinted below:

PREFACE.

This is a fac-simile of the unique manuscript of the Atharva-Veda in the version current in the school of the Pāippalādas, the so-called Pāippalāda-çākhā. The manuscript came from Kashmir in the north of India; the version of the Atharva-Veda contained in it seems to have been at home only in Kashmir itself; hence we have chosen as its title, "The Kashmirian Atharva-Veda."

A persistent native Hindu tradition reports that the Atharva-Veda once existed in nine versions or schools (çākhā, bheda, carana). It seems probable that the school differences involved were in most cases of slight importance; but not so in all cases. One of these schools is that of the Çāunakas; the text of the Atharva-Veda derived from the Çāunakas was published by Roth and Whitney in 1856, and a second time (with a valuable though fragmentary commentary) by Shankar Pandurang Pandit in 1895. The existing translations of this Veda are all based upon the one text of the Çāunaka school; our knowledge of the public and private antiquities and the folk-lore of ancient India, so far as it is derived from the Atharvan, suffers from the same limitation.

To Professor von Roth, one of the editors of the editio princeps of the Atharva-Veda, belongs in a peculiar degree the credit of the discovery of the second version of the Atharvan which is herewith presented to the public. Deeply impressed with the insufficiency and corruption of the first text, he persistently incited inquiry for more manuscripts. Somewhere in the immense country, or rather continent, of India, it seemed likely there would turn up another tradition, another version, more original, less corrupt, in any case different from the first. Especially the north of India seemed to him the most hopeful field of inquiry. A remark of the traveller Baron von Hügel led him to believe that a new version might be found in Kashmir. Baron von Hügel, in his work "Kaschmir und das Reich der Siek," vol. ii, p. 364, remarks that the Brahmins of Kashmir belonged to the Atterwan, or, as they said, "Atterman" Veda; upon the strength of this statement Roth induced the authorities of the British Government in India to institute a search in the distant earthly paradise, famous up to that time for the grandeur and beauty of its natural scenery rather than its literary treasures. His prophetic surmise came true most brilliantly. His Highness, the late Maharaja of Jammu and Kashmir, Ranbir Singh, announced that he had in his library at his capital city, Srinagar, a manuscript of the Atharva-Veda "written in character which could not be read by any one outside of Srinagar." Negotiations carried on by Sir William Muir, the then Lieutenant Governor of the North-Western Provinces, led first to the dispatch to Professor von Roth of a copy of the manuscript made in Devanāgarī character, and later on to the dispatch of the original in Çāradā character. Professor von Roth in 1875 published a stirring account of the discovery, character and contents of the manuscript in his famous tract "Der Atharva-Veda in Kaschmir" (Tübingen, 1875), and later read a paper on the same subject before the International Congress of Orientalists, held at Florence in 1878 (published 1881 in the Transactions of that Congress, vol. ii, p. 89 ff.) He guarded the manuscript until his recent lamented death (1895); it has now passed into the possession of the University Library at Tübingen, whose greatest and priceless treasure it forms.

The manuscript contains in round numbers 275 leaves written on both sides, making about 550 pages. The leaves are made of the bark of the birch-tree, known to botanists by the name of Betula Bhojpatra, or in Sanskrit, bhūrja-patra, which grows in the Himalaya mountains up to the height of nine thousand feet. The inner bark of this tree consists of several layers which may be successively detached. The strips obtained in this way serve as a natural yet fragile paper. In order to make them rather more durable, two strips are pasted together, back to back, yielding a sheet both sides of which are used for writing. As it is, even the doubled leaves break easily; not infrequently one of the faces of the leaf is chipped off while the other still holds out; this may be seen on several plates of this fac-simile. Books written on birch-bark are not likely to last very long; an old book falling to the ground is liable to suffer very seriously, if it does not break to pieces entirely. The use of birch-bark for literary purposes is mentioned by early classical Sanskrit writers, such as the poet Kālidāsa and the medical doctor Suçruta, the author of the Āyur-Veda. In early times, it seems, all books in Kashmir were written on birch-bark until after the conquest of the valley by the Mogul emperor Akbar, more than 250 years ago. Akbar introduced the manufacture of paper, an industry for which Kashmir is now famous in India. At that time the use of birch-bark for the purpose of writing came to an end; the method of preparing it is so completely forgotten that the Kashmirians can no longer produce birch-bark manuscript. The present manuscript is about 400 years old; it is in general in very good condition. Only a few leaves are lost, among them, unfortunately, the first; but beginning with the thirteenth page there is but little damage due either to the ravages of time or to careless handling. The following leaves or pages are wanting: 1^{ab}, 21^{ab}, 23^{a}, 62^{ab}, 120^{a}–129^{b}, 150^{ab}, 177^{ab}; in most of these cases, however, there is a gap, not in the text, but in the numbering of the leaves only.

The size of the leaves is for the most part about 25 centimetres in height by 20 in width. The space occupied by the text averages 20 centimetres in height by 15 in width, The writing is in indelible black ink, absolutely non-sensitive to damp and water; each page before exposure to the lens of the photographer was sponged off with water in order to make the very clear writing still clearer. The method of preparation of the ink is known. It was made by converting almonds into charcoal and boiling the water thus obtained with go-mūtra (urina bovis). The character is the so-called Çāradā, which seems to mean "letters sacred to Çāradā;" i. e. Sarasvatī, the tutelary goddess of instruction and writing. The alphabet is North Indian, from the same source as the more prevalent learned alphabet of India, the Devanāgarī. Its use seems to have been almost entirely confined to Kashmir and the north-eastern part of the Panjab. The difference between the Çāradā and the Devanāgarī is quite considerable. In particular the ligatures of the Çāradā, those vexing combinations of three and even four consonants, are easily confused and more difficult than those of the Devanāgarī. Two instructive tables containing transliterations of 340 characters and ligatures of the Çāradā script have been published by Karl Burkhard in the Proceedings of the Imperial Academy of Vienna (Historic-Philosophical Class), vol. cvii, after page 640.

The editors have much pleasure in presenting this manuscript to the public in a form as close to the original as it is possible in the present state of the art of bookmaking. The labor involved in the present edition was by no means merely technical or mechanical. Each plate was closely scrutinized and passed through laborious corrections. Naturally it will be the lot of the editors to follow up this first step with other labors, A transliteration of the text in Roman characters; a detailed comparison of the Kashmirian version with the vulgate text as hitherto known; and finally, if possible, a translation may be expected from their continued co-operation.

To the authorities of the Johns Hopkins University and the Royal Government of Württemberg the editors and the learned public owe a lasting debt of gratitude. Their enlightenment and generosity has made possible this publication. To the American Oriental Society, to the various branches of the British Government in India, and to many other institutions and persons we are indebted for liberal advance subscriptions. We also owe thanks to Mr. N. Murray, the Librarian of the Johns Hopkins University, and to Dr. C. Geiger, the Chief Librarian of the University of Tübingen, the keeper of the manuscript, for their unselfish aid at every stage of the undertaking.

The Editors.

JOHNS HOPKINS UNIVERSITY STUDIES

— IN —

HISTORICAL AND POLITICAL SCIENCE

(Edited by H. B. Adams, 1882–1901).

J. M. VINCENT,
J. H. HOLLANDER, W. W. WILLOUGHBY,
Editors.

PROSPECTUS OF TWENTIETH SERIES, 1902.

The University Studies will continue to publish, as heretofore, the results of recent investigations in History, Economics, and Political Science. The new series will contain monographs on colonial, revolutionary and early constitutional history. The cost of subscription to the regular Annual Series, comprising about 600 pages, with index, is $3.00. Single numbers, or special monographs, at special prices.

For the year 1902 the titles given below are now announced, and other numbers will follow from time to time.

STATE BANKS SINCE THE PASSAGE OF THE NATIONAL BANK ACT. By G. E. Barnett.
WESTERN MARYLAND IN THE REVOLUTION. By B. C. Steiner.
QUIT RENTS IN COLONIAL NORTH CAROLINA. By E. P. Kennedy.
EARLY HISTORY OF INTERNAL IMPROVEMENT IN ALABAMA. By W. E. Martin.
POLITICAL ACTIVITIES OF PHILIP FRENEAU. By S. E. Forman.

NEW EXTRA VOLUME.

An extra volume will be issued early in 1902 as a memorial of the late Professor Adams. This will contain biographical sketches and tributes from various writers and a Bibliography of the Publications by Graduates and members of the Department of History, Politics and Economics of the Johns Hopkins University from 1876 to 1901. This will be sent free to subscribers for the Series.

ANNUAL SERIES OF STUDIES IN HISTORY AND POLITICS, 1883-1901.

Series I.—Local Institutions. 479 pp. $4.00.
Series II.—Institutions and Economics. 629 pp. $4.00.
Series III.—Maryland, Virginia, and Washington. 595 pp. $4.00.
Series IV.—Municipal Government and Land Tenure. 600 pp. $3.50.
Series V.—Municipal Government, History and Politics. 559 pp. $3.50.
Series VI.—The History of Co-operation in the United States. 540 pp. $3.50.
Series VII.—Social Science, Municipal and Federal Government. 628 pp. $3.50.
Series VIII.—History, Politics, and Education. 625 pp. $3.50.
Series IX.—Education, Politics, and Social Science. 640 pp. $3.50.
Series X.—Church and State, Columbus and America. 630 pp. $3.50.
Series XI.—Labor, Slavery, and Self-Government. 574 pp. $3.50.
Series XII.—Institutional and Economic History. 626 pp. $3.50.
Series XIII.—South Carolina, Maryland, and Virginia. 606 pp. $3.50.
Series XIV.—Baltimore. Slavery and Constitutional History. 588 pp. $3.50.
Series XV.—American Economic History. 618 pp. $3.50.
Series XVI.—Anglo-American Relations and Southern History. 624 pp. $3.50.
Series XVII.—Economic History: Maryland and the South. 600 pp. $3.50.
Series XVIII.—Taxation in Southern States: Church and Education. 582 pp. $3.50.
Series XIX.—Diplomatic and Constitutional History. $3.50.

The set of nineteen series is now offered, uniformly bound in cloth, for library use, for $57.00. The nineteen series, with sixteen extra volumes, in cloth, will be sold for $75.00.

All business communications should be addressed to
The Johns Hopkins Press, Baltimore, Maryland.

PUBLIC LECTURES IN SCIENCE AND LITERATURE, 1901–1902.

The lectures described below are designed primarily for persons engaged in teaching, but others interested in the subjects are at liberty to attend.

PHYSICS.

Twenty lectures by Professor **Ames** on the History of the Principles of Physics, in the physical laboratory, Saturdays, at 11 a. m., beginning November 2.

Each lecture consists of a sketch of the life of some one man whose name is eminent in the history of science, or of the lives of a small group of men, with particular reference to his or their contributions to our present knowledge. So far as possible, the original experiments are repeated, and numerous other illustrative demonstrations accompany the lecture. This is followed immediately by a conference, in which is given an opportunity for consultation and more detailed explanations.

The subjects of the lectures are as follows:—

Copernicus, Tycho Brahé, and Kepler: early astronomy.
Galileo: the beginnings of science.
Torricelli and Pascal: properties of fluids.
Leonardo da Vinci and Stevinus: phenomena of mechanics.
Boyle and v. Guericke: properties of gases.
Newton and Huygens: the foundation of mechanics.
Davy and Rumford: the nature of heat effects.
Black and Regnault: measurement of heat.
Mayer, Carnot, and Clausius: thermodynamics.
Joule: the mechanical equivalent of heat.
Cavendish: law of gravitation and of electrical charges.
Galvani and Volta: discovery of electric currents.
Oersted and Ampère: the magnetic action of electric currents.
Henry and Faraday: induced electric currents.
Maxwell: properties of the ether.
Young and Fresnel: the wave-theory of light.
Fraunhofer and Kirchoff: spectrum analysis.
Plateau: capillary phenomena.
Helmholtz: physiologist, mathematician, physicist.
Rowland: modern physics in America.

GEOGRAPHY AND PHYSIOGRAPHY.

Two courses (of twenty lectures each) by Dr. **George B. Shattuck**, Associate in Geology, in McCoy Hall, Saturdays, from 9.30 to 11 a. m., beginning November 2.

Course A.

The object of this course of lectures is to discuss the natural resources and physiographic features of North America, to show how they depend on the underlying geologic structure, and to explain how this has influenced the migration of mankind and the spread of civilization across the continent. The topics are as follows:

The Environment.

1. Physiographic Features of North America.
2. Climatic Features of North America.
3. Continental Growth of North America.
4. Minerals and Soils of North America.
5. Botany of North America.
6. Zoölogy of North America.

The Migration.

7. Principles of Human Occupation.
8. History of Exploration in North America.
9. Settlement of Eastern North America.
10. Settlement of Western North America.

The Adjustment.

11. Communication in North America.
12. Agriculture in North America.
13. Forestry in North America.
14. Mining industries in North America.
15. Manufactures in North America.
16. Maritime Industries in North America.
17. Commerce in North America.
18. Education in North America.
19. Government in North America.
20. World Relations of North America.

Course B.

This course includes all of the lectures of Course A, and an additional series of twenty lectures on Physiography. The object of the lectures on Physiography is to discuss the processes which have been instrumental in bringing about the geologic changes on the earth's surface. Special emphasis will be placed on those points which teachers will find helpful in conducting observational work with their pupils. The lectures will be extensively illustrated with maps, charts, and stereopticon views. The topics are as follows:

1. The Geological work of the Atmosphere.
2. The Geological work of Rain.
3–4. The Geological work of Rivers.
5–6. The Geological work of Lakes.
7. The Geological work of Frost and River Ice.
8–9. The Geological work of Icebergs and Glaciers.
10–11. The Geological work of Oceans.
12–13. The Geological work of Volcanoes.
14–15. Mountain Growth.
16–17. Fossils and their Meaning.
18–19. Minerals and Rocks.
20. The Geology of Baltimore and Vicinity.

BOTANY.

Instruction in Botany by Dr. **Duncan S. Johnson**, Associate Professor of Botany, in the biological laboratory, Saturdays, at 10.30 a. m., beginning November 23.

The course consists of nineteen lectures and laboratory exercises and one field trip, and is devoted to the study of the life-histories of the Club-Mosses and of the Flowering-Plants taken up under the following topics:

Introductory.—The work of plants, growth, reproduction, alternation of generations, the great groups of plants, and the three groups of Fern-plants.
Structure and life-history of the large Club-Moss (Lycopodium).
Structure and development of the small Club-Moss (Selaginella).
Life-history of the Quill-wort (Isoetes).
Structure and development of the Sago-palm (Cycas or Zamia).
The Ginkgo or Maidenhair-tree.
Development of the Yew (Taxus).
Development and structure of the Larch, Pine, and Spruce (Larix, Pinus, and Picea).
The Cedars and Cypresses (Juniperus, Thuya, Taxodium, etc.).
The Gnetums and Ephedras.
The Angiosperms: vegetative organs, habit, flower, and fruit.
Structure and development of a Monocotyledon (Lilium).
Life-history of the Knotweed and Lizard's-tail (Polygonum and Saururus).
Structure and germination of seeds, the function of fruit, etc.

ENGLISH LITERATURE.

Eighteen lectures on English Literature by Dr. **Frederick H. Sykes**, Lecturer of the American Society for the Extension of University Teaching, in McCoy Hall, Fridays, at 7.30 p. m., beginning November 8.

The general subject is the "Literature of the Victorian Era," and the special themes are as follows:—

I. *The Victorian Poets.*
1. Lord Tennyson.
2. The Oxford Poets: Clough and Matthew Arnold.
3. Elizabeth Barrett Browning; Christina Rossetti.
4. Robert Browning.
5. The Pre-Raphaelites: D. G. Rossetti, William Morris, Swinburne.
6. Later Poets: Watson, Stevenson, Austin, Kipling.

II. *English Writers of the Present Era.*
1. Thomas Carlyle.
2. Cardinal Newman.
3. Charles Kingsley.
4. John Ruskin.
5. Matthew Arnold.
6. Rudyard Kipling.

III. *The Modern English Novel.*
1. Robert Louis Stevenson.
2. Charles Dickens.
3. William Makepeace Thackeray.
4. George Eliot.
5. George Meredith.
6. Thomas Hardy.

A syllabus of each of these three series is given to subscribers to the lectures.

LATIN.

Two courses (of twenty lessons each) by Dr. HARRY L. WILSON, Associate in Latin.

COURSE FOR BEGINNERS.

In this course, as far as time permits, a thorough training in the fundamental facts and principles of the language is imparted, and the instruction is of such a nature that those who desire it may proceed in the following year to work of a more advanced character. The study of Latin grammar, Latin prose composition, and, later in the year, of some easy text, forms the basis of the work. No previous knowledge of the language is assumed.

The class meets in Room 15, McCoy Hall, Tuesdays at 5.15 p. m., beginning November 12.

COURSE FOR ADVANCED STUDENTS.

This course includes the study of such authors as the wants and previous training of the students may require. The reading of texts is as rapid as circumstances permit, and is accompanied by brief commentary and occasional talks on topics of interest.

The class meets in Room 15, McCoy Hall, Tuesdays at 4.15 p. m., beginning November 12.

CLASSICAL LITERATURE.

Professor RICHARD G. MOULTON, Ph. D., of the University of Chicago, will deliver six lectures on "Ancient Tragedy for English Audiences," in McCoy Hall, at 5 p. m., on successive Wednesdays, beginning January 8, 1902.

TOPICS.

January 8.	Shakespere's Macbeth in the form of an Ancient Tragedy
January 15.	Double Recital: Aeschylus's Trilogy, 'Story of Orestes.'
January 22.	Recital: The 'Electra' of Sophocles.
January 29.	Recital: The 'Electra' of Euripides.
February 5.	Recital: The 'Alcestis' of Euripides.
February 12.	The Theatre as the Church of Ancient Greece.

A list of books suitable for reading in connection with the lectures, and suggestions for further study, are given in the syllabus, which is intended to serve as a text-book to the course.

LECTURES ON UNIVERSITY EDUCATION,

BY

DANIEL C. GILMAN, LL. D.,

President Emeritus of the Johns Hopkins University.

Dr. Gilman will deliver a course of lectures on topics pertaining to *University Education*, in the Donovan Room, on successive Saturday mornings, beginning January 11, 1902, at half-past 9 o'clock.

These lectures are primarily intended for those of the younger instructors and those graduate students who may be interested in the development of academic life in the United States. Although to some extent historical, they will have a practical bearing upon present problems, interesting to those who are looking forward to careers in colleges and universities. The following topics will be considered:—

I.

Washington's Idea of a National University.—How it has been hindered and how it has been fostered.
Saturday, January 11.

II.

Original Research.—Its antiquity. Its modernity. Its importance. Its opportunities and its methods.
Saturday, January 18.

III.

Scholarships, Fellowships, Burses, and Prizes.
Saturday, January 25.

IV.

Academic honors and rewards. The utility and the futility of Degrees.
Saturday, February 1.

V.

Scientific Publications.
Saturday, February 8.

VI.

The great benefactors of American Education.
Saturday, February 15.

ALBERT SHAW LECTURES ON DIPLOMATIC HISTORY.

The Albert Shaw Lectures on Diplomatic History for 1902 will be given by Professor GEORGE M. FISK of Tome Institute, on the "History of the Commercial Relations of Germany and the United States."

The first lecture will be given on Monday, January 13, at 11 o'clock, in Room 23, and will be continued on successive Mondays at the same hour until March 31.

MARYLAND COLONIAL HISTORY.

The second course of lectures on Maryland Colonial History, provided by the liberality of the Maryland Society of the Colonial Dames of America, will be given by CLAYTON COLMAN HALL, LL. B., of the Baltimore Bar. The lectures will be given in McCoy Hall, on Mondays at 5 p. m., beginning February 17. The general subject to be treated is "The Lords Baltimore and the Maryland Palatinate." The specific topics and the dates are as follows:

February 17.	George Calvert, first Lord Baltimore, 1580–1632.
February 24.	Cæcilius, second Lord Baltimore, 1606–1675.
March 3.	Religious Toleration in Maryland.
March 10.	Charles, third Lord Baltimore, 1630–February 20, 1715. The Royal Governors.
March 17.	Benedict Leonard, fourth Lord Baltimore, died April 5, 1715. Charles, fifth Lord Baltimore, 1699–1751. Frederick, sixth Lord Baltimore, 1732–1771.
March 24.	Manners, Customs, and Social Conditions in Maryland during the Colonial Period.

NOTES IN PHILOLOGY.

THE NEGATIVE COMPOUNDS IN GREEK.

By H. A. Hamilton.

[Abstract of a Dissertation submitted for the Degree of Doctor of Philosophy.]

The compounds of alpha-privative make one of the largest groups and one of the simplest types of composite word-formation in Greek and this study is intended to afford a single chapter in the history of noun-composition in that language. The subject is approached from the formal, the semantic, the stylistic and the historical side.

Formally, the Greek negative prefix is the representative of that weaker form of the Indo-European negative which was prefixed to the noun and adjective. Greek agrees with Sanskrit and Avestan in having the form of *ἀν-* (*an-*) before vowels and *ἀ-* (*-a-*) before consonants. *ἄϋπνος* (Hom.) and *ἄοικος* (Hes.) are only apparent exceptions, since they were formed in a period when initial *σ* and *Ϝ* still existed in the simple words. With regard to the lengthening of the prefix in a few old words, as *ᾱ̓θάνατος*, it is likely that we have to do with a phenomenon parallel with *ἠνεμόεις* from *ἄνεμος*, the result of a tendency toward a lengthening of short vowels of which the poet availed himself under stress of metrical necessity. The old poetic prefix *νη-* and the very rare *ἀνα-* (as in *ἀνάεδνος*) are probably not derived from any Indo-European forms of the prefix but are secondary developments within the Greek language, perhaps due to the process known as "clipping."

The words containing the negative prefix may be classified as follows: I. Immutata (determinatives), *α*-priv. with ordinary adjectives, verbals in *-τος*, other participles, or nouns, e. g. *ἀβάρβαρος*, *ἄβατος*, *ἀέκων*, *ἀδώτης*. II. So-called synthetica, *α*-priv. with verbal root, e. g. *ἄτριψ*. III. Mutata (so-called possessives), *α*-priv. with noun, with or without new adjectivizing suffix, e. g. *ἄθυμος*, *ἀθεμίστιος*. IV. Derivative words, nouns, adjectives, adverbs, verbs, and new compounds, e. g. *ἀεργία*, *ἀεργηλός*, *ἀεκητί*, *ἀδυνατέω*, *ἀδικοπραγής*.

The true sphere of the negative prefix is its combination with nouns, adjectives and verbal stems to form adjective compounds. The nouns and verbs with *α*-priv. are in general not compounds at all, but are derivatives from compound adjectives. The prefix can never properly be combined with the verb to form a negative verb, nor with a pronoun or pronominal word to form an indefinite pronoun. The infinitives and participles being nominal in their origin must at first have taken the negative prefix and not the negative adverb. But, in general, composition with the negative prefix declines when the participle, as in Greek, becomes more closely attached to the verb and assumes more of verbal and less of adjectival character. The infinitive in Greek has become too distinctly verbal in its nature to take the prefix and the negation of the finite verb in Greek by an *α*-priv. is to be looked upon as an anomaly. So too the prefix is only irregularly and exceptionally combined with nouns to form nouns; regularly a compound of *α*-priv. + noun is an adjective. Rare forms like *ἀτίω* (*τίω*), Theogn. 621, and *ἀδώτης* (*δώτης*), Hes. Op. 355, are artificial compounds made for the sake of antithesis to the simple words just preceding and so are hardly amenable to the ordinary laws of formation. So negative abstracts are not formed directly from their corresponding positives; *ἀδικία*, not **ἀ-δικη*, is the negative of *δίκη* and is derived therefrom through the compound *ἄδικος*. With ordinary adjectives (excluding verbals in *-τος*) the combination of the negative prefix is by no means free and generally productive, but of the whole number of words containing the prefix the proportion consisting of combinations of *α*-priv. + adj., especially in the best period, is small; for the whole literature it is only between 8 per cent. and 9 per cent. Many undoubtedly old adjectives do not make any negative compounds at all, but have their opposites expressed by positive words, as *μέγας*, *μικρός*. So generally with adjectives having a physical sense. Many derivative adjectives find their opposites in a negative possessive compound or mutatum; thus the opposite of *δίκαιος* is not **ἀ-δικαιος*, but *ἄδικος*. In respect to meaning the following proportion is typical of a large number of groups: *δίκη* : *δίκαιος* = *ἀδικία* : *ἄδικος*.

The favorite Greek types of compound with the negative prefix are those with the verbals in *-τος* and the mutata (or possessives) made up of prefix and noun. Both of these types were Indo-European and were apparently the most common types in the pro-ethnic speech also.

The negative compound may be replaced by a complex with a negative adverb or by other forms of expression which, though not negative in form, are so or nearly so in effect. The negative of the sentence and of the verb may in various ways become extended in its use to other parts of speech—the so-called *οὐ*-privative, Thompson, Gr. Synt., §§ 280–1. We have what are nearly compounds in *οὐκ ἐθέλων*, *οὐκ ὀνομαστός* and in *οὐχ ἅλιος*, a common litotes in Homer. The reluctance of the Greek to form immutata (or determinatives) of *α*-priv. + noun accounts for expressions like *τὴν οὐ περιτείχισιν*, Thuc. III, 95, 2. Compare the Latin *nescius*, *nefas*, *negotium*. Various conditions operated to make this use of the negative adverbs a part of the language's ordinary means of expression. Such a combination was less permanent and more readily produced than a compound with the negative prefix and would often be used where no corresponding compound with the prefix was in familiar use or, if it was, could not be used in certain metres. Often too the combination with the negative adverb had to be employed to denote the negation of a quality where the compound with the prefix had come to signify its opposite. By the figure of under-statement, of which the Greeks were fond, the compounds in *δυσ-*, *κακο-* and *ὀλιγο-* were sometimes employed where a strictly negative expression would not be improper. Compounds with certain prepositions, as *ἀπό*, *ἐξ*, *παρά*, may be in effect negative and *ὑπό* in composition with an adjective has often a minimizing force comparable with that of the diminutive suffix in nouns, as *ὑπόλευκος*. Many compounds with certain verbal and adjective stems as first members are practically negative and are mostly poetic in the classical period, e. g., *φυγόμαχος*, *λιπόσκιος*, *ἐρημόπολις*, *κένανδρος*. The negative abstract noun and the negatived articular infinitive have a partial coincidence in function, but the coincidence is only partial; cf. Prof. Gildersleeve in Trans. Am. Philol. Assn., 1878, p. 18.

Semasiologically, the negative compound differs from the complex with the negative adverb in that in the former the individuality of the component elements is lost to the consciousness and the combination itself becomes the conventional sign for a single notion. When this state of affairs has been reached the compound adjective may become used as an attributive or as a mere epithet. That which denotes the absence of a quality may come to denote its contrary and may finally through usage acquire a positive content of its own. In the earlier stages of language qualitative opposites are expressed rather by words from different roots than by a word and its formal negative. The production of new negative compounds is often an indication of reflectiveness or of an affected striving for precision, or again of a desire for euphemism in expression or litotes. Frequently there is an hyperbole in their use, as when a coward is called ἀκάρδιος, or a barbarian ἄγλωσσος.

In some instances the negative compounds seem to be analyzed in the consciousness of the user, so that the prefix is felt with almost the force of a sentence-negative, as when such a negative compound justifies a following πρίν with a finite mood, or as in Eur. Androm. 745–6, where the negative in ἀδύνατος is reinforced by another negative, οὐδέν.

Stylistically, the negative compounds not only have the effect which is common to compounds in general but they also have a stylistic character which is peculiarly their own. Greek was far more moderate than the later Sanskrit in availing itself of its capacity for making compounds. A Sanskrit compound has often hardly more of a permanent characterizing force than the more readily extemporized syntactical combinations of words, but the use of a new compound by a Greek author is a distinct exercise of the creative faculty in language and we see the compounds entering the literature in those spheres where the creative faculty has the greatest activity. One of those spheres is that of the ποιητής, whose language thus acquires an impressiveness and dignity which is above the level of ordinary speech. This use of compounds reached its extreme in the dithyramb, in which the striving after vague expression realized itself in the large use of compounds, which have naturally a more implicit character than the corresponding syntactical combinations. This tendency is seen too in tragedy, especially in the choral parts, and in the exaggerations and parodies of comedy. The second great sphere of creativeness in the production of compound words is the language of those who deal with subjects more or less technical. The negative compounds are especially prominent in the philosophical and scientific literature, as for example in many of the writings of the Hippocratean corpus. In later Greek the poetic or technical feeling of the older types of compound was largely lost, and the poets made their usage more poetic by multiplying compounds of unusual types e. g. λιπόσκιος, Nonnus, = ἄσκιος. But the compounds of the poets do not tend so much to sink to the common level as do the technical words, the former being the creations of art and feeling rather than due like the latter to the necessities of expression.

The form and meaning of the negative compounds lent themselves easily to special stylistic effects. This is very noticeable where these words are massed two or more together (very often in threes), making the figures both of alliteration and anaphora. If the privation relates to one of the chief objects of human interest, the compounds have a pathetic character which is heightened by repetition; so Il. 9, 63–4:

ἀφρήτωρ ἀθεμίστιος ἀνέστιός ἐστιν ἐκεῖνος,
ὃς πολέμου ἔραται ἐπιδημίου ὀκρυόεντος.

This figure is a great favorite with the tragic poets, and Ar. Ran. 204 is doubtless paratragedy; many examples might be cited from the orators. The frequency of this phenomenon in the English poets has long been a subject of remark. The negative compounds often occur in the *figura etymologica*, a figure which doubtless had its beginnings in the older popular language, which survived in tragedy, and which was used occasionally by most of the orators; so ἄφιλος φίλων, Eur. Hel. 524. There was developed in Greek a form of the *figura etymologica*, an oxymoron, which created for itself a special set of negative compounds; the earliest example is in Od. 18, 73, Ἶρος Ἄϊρος. Here Froehde, Bezz. Beitr. 20, 216, would read ἄϝιρος = Skt. *avīras*, "unmanly." This pun is followed by more than a score of similar expressions in later authors, chiefly the tragedians, as νᾶες ἄναες, Aesch. Pers. 680. Here, however, we have not puns, but simple *figura etymologica*. The figure became a recognized element of tragic diction and a part of the literary tradition of the language. Aristotle, Rhet. III, 6, 7, 1408a, and III, 11, 11, 1412b, speaks of μεταφοραὶ ἐκ τοῦ ἀναλόγου, proportional metaphors, as affording a special sphere for the use of negative words, so e. g. in Aesch. Sept. 82, the dust, κόνις, is called ἄναυδος ἄγγελος. The opposition in the very nature of the negative words made them a ready means for the expression of antithesis, a figure native to the Greek. Here we often have also paronomasia and rhetorical balancing, e. g. ἔργον δ' οὐδὲν ὄνειδος, ἀεργίη δέ τ' ὄνειδος, Hes. Op. 311. The examples of these words in litotes are very common from Homer down, as in Homeric οὐκ ἄφρων, etc.; ἀμελέω is always used with a negative in Homer. Sometimes the phonetic effectiveness of the compounds is increased by adding an element which, while making greater the number of syllables, contributes little to the sense, so ἀπειρόγαμος, hardly different from ἄγαμος, ἀδικοπραγής, nearly = ἄδικος. Such an extension of words is quite characteristic of the solemn diction of the old religious poetry.

Fick in his Wörterbuch der Indogermanischen Sprachen^4, I, pp. 85, f., gives a list of 10 negative compounds which the Greek had in common with the pro-ethnic speech, which list may have some slight value bearing on the history of the formation of these words in Greek. A comparison of the phrase κλέϝος ἄφθιτον, Il. 9, 413 with the Sanskrit *çravas akṣitam* gives strong proof of the high antiquity of ἄφθιτος.

Tables, which cannot be reproduced here, have been prepared, showing the emergence of new negative words in the literature by authors, periods, or departments, and by classes (see classification above); also showing the percentage of new negative words by classes in various groups of authors. The total number for all the literature is 4029, or, not including derivatives, 3058. 15 per cent. of all the words given by Liddell and Scott appear in the literature before 500 B. C.; 26.8 per cent. appear in the Attic period and 7 per cent. in the Alexandrian, making a total of 48.8 per cent. before the Roman period. Thus a very large proportion of the negative words belong to the post-classical period; they abound in ecclesiastical and technical literature. The only authors or groups of authors of the classical period in whose writings 100 or more of these negative words appear for the first time are: Homer, Aeschylus, Sophocles, Euripides, the Hippocratean writings, Plato, Aristotle. But the conservative vocabulary of the orators furnishes only 87 new words altogether (Antiphon gives 22). The great majority of the negative compounds in Homer are either verbal compounds of the type, ἀδάμαστος, or secondary possessives of the type, ἄφυλλος. We observe relatively a quite steady advance of the later language beyond the earlier in the making of the compounds in -τος and a still more striking falling off in the introduction of new possessives. These changes are most noticeable in prose. Thus in Homer and early lyric poetry the possessives are the more numerous, but the relation is reversed in Hesiod, Aeschylus, Pindar and Bacchylides, while in the fragments of early philosophy, history and comedy, the shift is very much more marked. For the whole period before the fifth century the proportions are about equal. In tragedy after Aeschylus the possessives again predominate; also in the Ionic Herodotus and Hippocrates, but nowhere else except in the highly poetic spheres of the Anthology and the oracles, with a very slight preponderance in Alexandrian poetry. In comedy, Plato, Xenophon and Aristotle, the -τος compounds predominate, and in Thucydides and the orators the percentages of possessives are far down to about the level of late Greek. In the fragments of philosophy and in inscriptions the proportion of possessives is lowest. The large use then of the possessives in preference to the verbals in -τος is clearly poetic and may perhaps be Ionic. Many of the possessives belong to the higher ranges of literature, and never gained currency in prose. It seems to have been distinctly more common in the older language to coin a possessive from a noun than to make a new verbal in -τος from the verb which corresponded to the noun. Yet as early as Homer we find a number of pairs like ἄπυρος, ἀπύρωτος. The possessives predominate in the νη- compounds, which have a poetic and archaic character. Of negative abstract nouns the highest percentage is Plato's, while the lowest percentages are those of the poets.

PROCEEDINGS OF SOCIETIES.

Philological Association.

December 13, 1901.—One hundred and ninety-fourth regular meeting. Professor Gildersleeve in the chair. Fifty-two members were present.

Papers read:

Literary Adaptations in Gerhart Hauptmann's *Versunkene Glocke*. By H. Wood.
Notes on Some Recent Contributions to Greek Philology. By B. L. Gildersleeve.

January 17, 1902.—One hundred and ninety-fifth regular meeting. Professor Gildersleeve in the chair. Forty-six members were present.

Papers read:

The Fable of the Peacock and Juno. By A. E. Curdy.
Erotic Poetry in the Old Testament. By P. Haupt.

Historical and Political Science Association.

December 6, 1901.

An Illustrated Talk on Porto Rico. By J. H. Hollander.
Hart's Foundations of American Foreign Policy. By N. Boyer.
Lowery's Spanish Settlements in the U. S. (1513–1561). By J. S. Moore.
George's Relations of Geography and History. By J. F. Bledsoe.

January 10, 1902.

Early History of the Wabash Trade Route. By E. J. Benton.
Halphen's Les institutions judiciares en France au XI^{e} siècle. By J. J. Crumley.
Ditchfield's English Villages. By R. H. Wright.
Curtis's The True Thomas Jefferson. By P. Hollis.
Conklin's American Political History to the Death of Lincoln. By J. L. Bost.

January 24, 1902.

Social Progress and the Police Powers of the State. By B. J. Ramage.
Bryce's Studies in History and Jurisprudence. By G. Cator.
Jusserand's L'Epoque de la Renaissance en Angleterre (La Revue de Paris, 15 Decembre, 1901). By N. Boyer.
Glover's Life and Letters in the Fourth Century. By T. J. Stubbs.
Fisher's The True William Penn. By J. M. Wright.

TWENTY-FIFTH ANNIVERSARY.

About two years ago it was decided to celebrate the twenty-fifth anniversary of the foundation of this University. The resignation of President Gilman and the uncertainties that followed made it appear undesirable to hold the celebration in February, 1901, and it was postponed until October. As the new President was not elected until June, and there was not sufficient time between the date of his election and October to make the necessary preparations, it was agreed to postpone the celebration until February, 1902, and to combine it with the inauguration of the new President.

A committee consisting of Messrs. Remsen, Gilman, Gildersleeve, Griffin, Haupt, Welch, Osler, Elliott, Clark, and Ames, has been arranging the details, and the indications are that the occasion will be one of great interest to all friends of the University.

The committee has kept prominently in mind the idea that this is intended mainly as a reunion of the alumni, and of others who have in some way been connected with the work of the University. The preliminary programme is as follows:

Friday, February 21.

3 p. m. Public assembly in Music Hall.

Commemorative address by Dr. Gilman, President Emeritus,
and other exercises.

9 p. m. Reception and Conversazione in McCoy Hall.

Saturday, February 22.

11 a. m. Public Assembly in Music Hall.

Inaugural address by President Remsen,
and other exercises.

7 p. m. Alumni Banquet in Music Hall.

There will be a reunion of the Historical Seminary on Thursday evening, February 20, 1902, at 8 o'clock, in the Historical Library. This will be a gathering of former graduate students in History, Economics and Politics, and will be held in connection with a regular meeting of the Historical and Political Science Association, which enters upon its twenty-fifth year. The time is made convenient for Alumni attending the anniversary of the University.

CONTENTS.

PAGE.
Notes from the Biological Laboratory:—
  Relationships of the Rugosa (Tetracorolla) to the Living Zoantheae (with twelve figures in text). By J. E. Duerden, - - - - - - - - 19
  On the Anatomy and Histology of a New Form of Cladonema from the Bahamas (with one plate). By H. F. Perkins, - - - - - - - 25
Photographic Reproduction of the Kashmirian Atharva-Veda, - - - - - - 28
Public Lectures in Science and Literature, - - - - - - - - - 30
Lectures on University Education, by President Gilman, - - - - - 31
Albert Shaw Lectures on Diplomatic History, - - - - - - - - 31
Lectures on Maryland Colonial History, - - - - - - - - - 31
Notes in Philology:—
  The Negative Compounds in Greek. By H. A. Hamilton, - - - - 32
Proceedings of Societies, - - - - - - - - - - - - - 34
The Twenty-fifth Anniversary, - - - - - - - - - - - 34

The Johns Hopkins University Circulars are issued monthly. They are printed by JOHN MURPHY COMPANY, No. 44 West Baltimore Street, Baltimore. Subscriptions $1.00 *a year, may be addressed to THE JOHNS HOPKINS PRESS,* Baltimore; *single copies will be sent by mail for ten cents each.*